The Fire Model Intercomparison Project (FireMIP)

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Global fire models

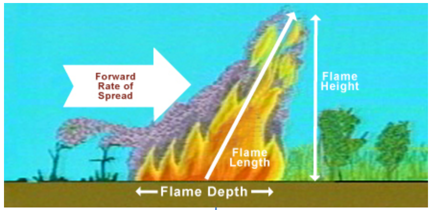
Weather, live vegetation, dead fuel, human population, land cover, etc.

Empirical global fire models

e.g. BA = climate * fuel * humans

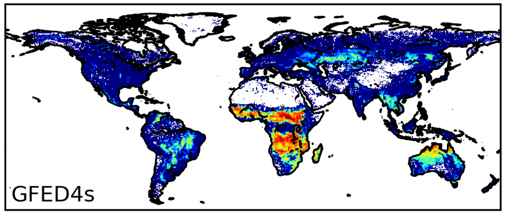
Process based global fire models

Modeling individual fire spread

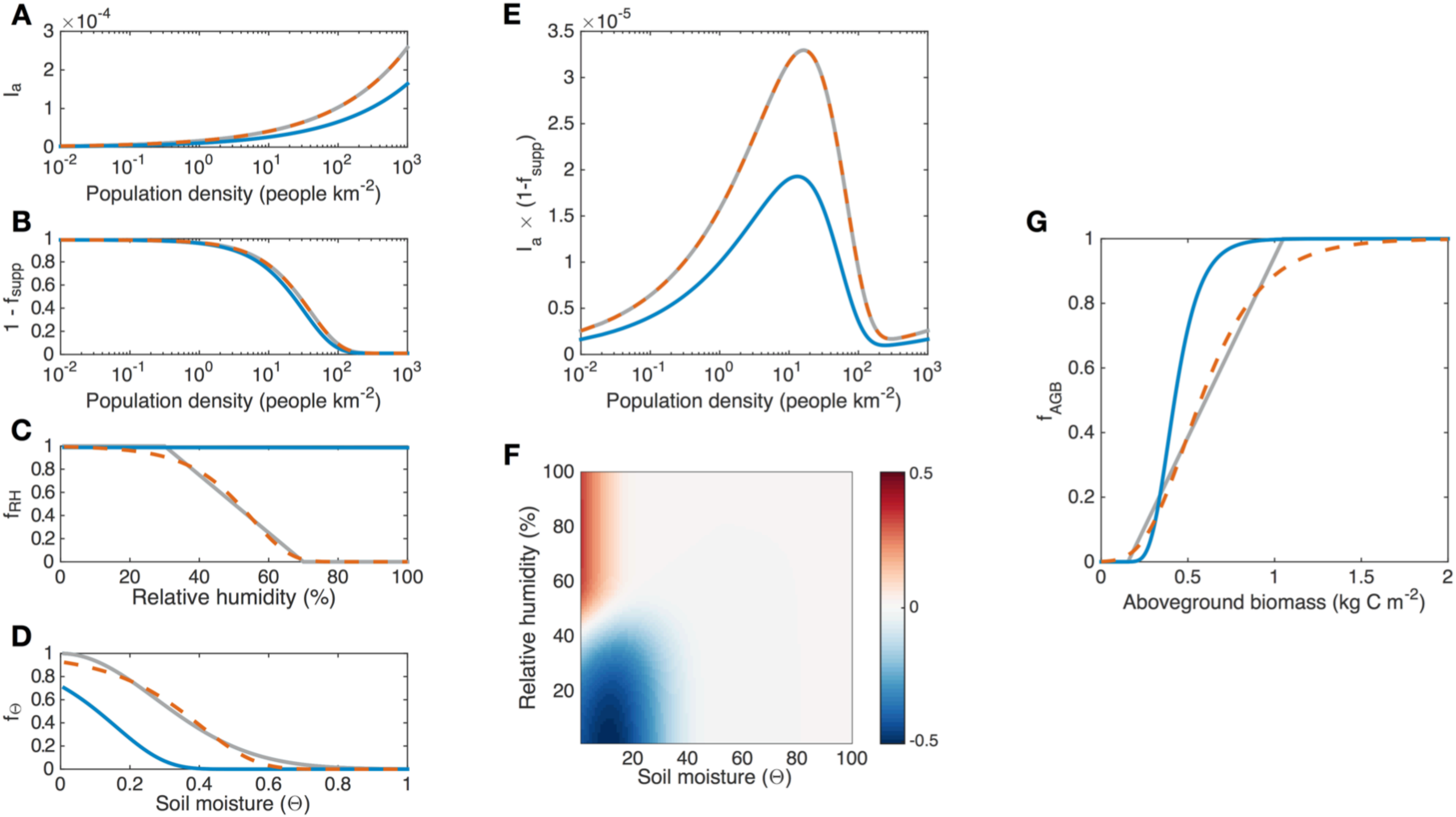


Upscaling to gridcell level

Global fire occurrence



Process-based models



Rabin et al. (2018)

Global fire models over the years

and more…

Global Ecology & Biogeography (2001) 10, 661–677

ETEMA SPECIAL ISSUE

The role of fire di

coupling fire into

A fire model with distinct crop, pasture, and non-agricultural burning: use of new data and a model-fitting algorithm for FINAL.1

Sam S. Rabin[1,2], Daniel S. Ward[3,a], Sergey L. Malyshev[3], Brian I. Magi[4], Elena Shevliakova[3], and Stephen W. Pacala[1]

MCFire Model Technical Description

David R. Conklin, James M. Lenihan, Dominique Bachelet, Ronald P. Neilson, John B. Kim

A mo

LPJ-LMfire (v1.0)

M. Pfeiffer[1], A. Spessa[2,3], and J. O. Kaplan[1]

Mo... incorporating SPITFIRE into the global vegetation model ORCHIDEE – Part 1: simulating historical global burned area and fire regimes

C. Yue[1,2], P. Ciais[1], P. Cadule[1], K. Thonicke[3], S. Archibald[4,5], B. Poulter[6], W. M. Hao[7], S. Hantson[8,9], F. Mouillot[10], P. Friedlingstein[11], F. Maignan[1], and N. Viovy[1]

The Fire Model Intercomparison Project is born

- Led from KIT by Stijn Hantson (now UC Irvine) and Prof. Almut Arneth
- First workshop September 2014

Biogeosciences, 13, 3359–3375, 2016
www.biogeosciences.net/13/3359/2016/
doi:10.5194/bg-13-3359-2016

Biogeosciences
Open Access
EGU

The status and challenge of global fire modelling

Stijn Hantson[1], Almut Arneth[1], Sandy P. Harrison[2,3], Douglas I. Kelley[2,3], I. Colin Prentice[3,4], Sam S. Rabin[5], Sally Archibald[6,7], Florent Mouillot[8], Steve R. Arnold[9], Paulo Artaxo[10], Dominique Bachelet[11,12], Philippe Ciais[13], Matthew Forrest[14], Pierre Friedlingstein[15], Thomas Hickler[14,16], Jed O. Kaplan[17], Silvia Kloster[18], Wolfgang Knorr[19], Gitta Lasslop[18], Fang Li[20], Stephane Mangeon[21], Joe R. Melton[22], Andrea Meyn[23], Stephen Sitch[24], Allan Spessa[25,26], Guido R. van der Werf[27], Apostolos Voulgarakis[21], and Chao Yue[13]

FireMIP goals & expected outcomes

- Test the ability of models to reproduce current patterns and historical trends of fire occurrence and impacts
- Compare models' performance to identify which model structures seem particularly useful, and where more development should be focused
- Generate estimates (with uncertainty) of fire patterns and trends in the deep past (LGM), 20th century, and 21st century

FireMIP principles

- Unified input data for climate, CO_2, population, and lightning
- Observational data for evaluation should be independent of any models
- Benchmarking after Kelley et al. (2013) for standardized comparison metrics

FireMIP phase 1

- Focus on 1901 to present
- Transient 1700-2013 runs with time-evolving input data.
- *Sensitivity runs:*
  - *World without fire.*
  - *Pre-industrial fire regime.*
  - *Pre-industrial atmospheric CO_2.*
  - *Fixed human population density.*
  - *Fixed 1901-1920 lightning.*
  - *Fixed 1901-1920 climate.*
  - *Fixed 1700 land use.*

Rabin et al. (2017, *Geosci. Mod. Dev.*)

Model structure comparisons

Table 2. List of models participating in FireMIP, including contact person's email and key references. Also included is information relating to the configuration to be used in this phase of FireMIP. Note that "Resolution" refers to spatial and temporal resolution of the fire model only; the associated land or vegetation may update more frequently.

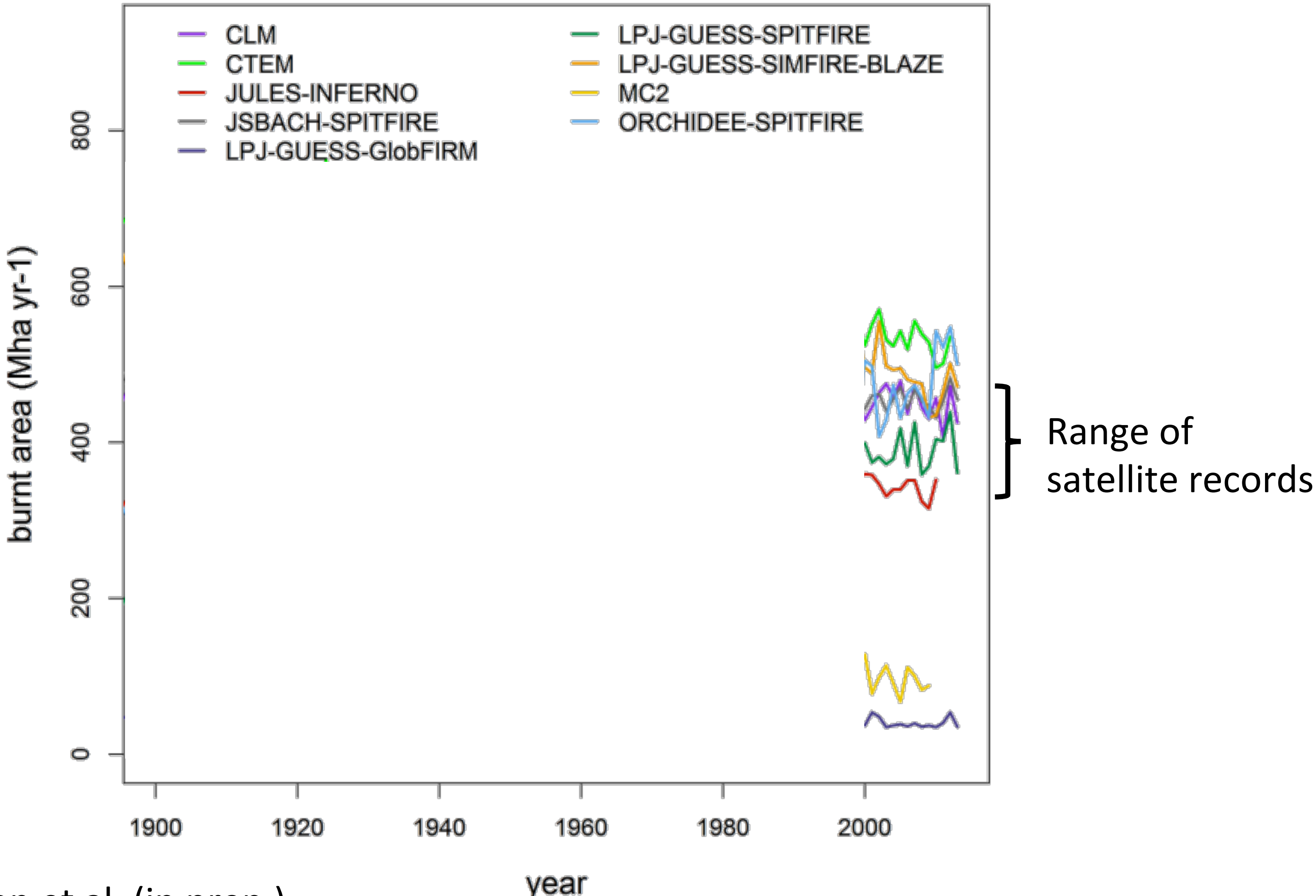
Fire model	Land/vegetation model	Dynamic vegetation			N cycle?	No. PFTs	No. soil layers	No. litter classes	Resolution	Contact
		Physiology	LAI, biomass	Biogeography						
CLM-Li fire module (Li	CLM4.5–BGC (Oleson	Yes	Yes	Yes, but not	Yes	17	15	1	~1.9° lat.	Fang Li (lifang@mail.iap.ac.cn)
MC-Fire	MC2 (Bachelet et al., 2015; Sheehan et al., 2015)	Yes	Yes	Yes	Yes	39	Depends on total soil depth	5	0.5°, monthly	Dominique Bachelet (dominique@consbio.org)
ORCHIDEE-SPITFIRE (Yue et al., 2014, 2015)	ORCHIDEE	Yes	Yes	Yes, but not in FireMIP	No	13	2	2	0.5°, daily	Chao Yue (chao.yue@lsce.ipsl.fr)

Table S13. Calculation of fractional combustion for models that classify dead fuels by size. Note that differences among SPITFIRE-based models in combustion of live fuels arose as a result of inconsistencies in Thonicke et al. (2010). PFT-specific values (Tables S20, S25–S28) are denoted with a "hat." "n/a" indicates models that do not include the indicated variable or concept.

Component	JSBACH-SPITFIRE	LPJ-GUESS-SPITFIRE	LPJ-LMfire	MC-Fire	ORCHIDEE-SPITFIRE
$FC_{d,1h}$	$G_{ag}\times(1-\mu_S)\times\begin{cases}1.0 & \omega_{ff/*}<0.18\\ X-0.62\omega_{ff/*} & 0.18\le\omega_{ff/*}\le0.73,\\ 2.45-2.45\omega_{ff/*} & \omega_{ff/*}>0.73\end{cases}$ where $X=1.11$.	As JSBACH-SPITFIRE, but using $\omega_{d,1h/*}$ instead of $\omega_{ff/*}$, and without multiplying by $(1-\mu_S)$.	As JSBACH-SPITFIRE, but with $X=1.10$ and using $\frac{\omega_{d,1h}}{0.404}$ instead of $\omega_{ff/*}$.	$0.9\times G_{ag}$	$G_{ag}\times\begin{cases}min\left(0.9,1.11-0.62\omega_{ff/*}\right) & \omega_{ff/*}\le0.73\\ 2.45-2.45\omega_{ff/*} & \omega_{ff/*}>0.73\end{cases}$
$FC_{d,10h}$	$G_{ag}\times(1-\mu_S)\times\begin{cases}1.0 & \omega_{o/*}<Y\\ 1.09-0.72\omega_{o/*} & Y\le\omega_{o/*}\le0.51,\\ 1.47-1.47\omega_{o/*} & \omega_{o/*}>0.51\end{cases}$ where $Y=0.13$.	As JSBACH-SPITFIRE, but with $Y=0.12$ and without multiplying by $(1-\mu_S)$.	As JSBACH-SPITFIRE, but with $Y=0.12$ and using $\frac{\omega_{d,10h}}{0.487}$ instead of $\omega_{o/*}$.	$\frac{-0.048132+(0.917393\times L_{d,10h}\times Z)}{L_{d,10h}\times Z}$, where conversion factor $Z=0.5\times0.224170$ converts from $kg\,C\,m^{-2}$ to $T\,DM\,ac^{-1}$.	$G_{ag}\times\begin{cases}min\left(0.9,1.09-0.72\omega_{o/*}\right) & \omega_{o/*}\le0.51\\ 1.47-1.47\omega_{o/*} & \omega_{o/*}>0.51\end{cases}$
$FC_{d,100h}$	$G_{ag}\times(1-\mu_S)\times min\left(0.45,[0.98-0.85\times\omega_{d,100h}]\right)$	$\begin{cases}0.98-0.85\omega_{o/*} & \omega_{o/*}\le0.38\\ 1.06-1.06\omega_{o/*} & \omega_{o/*}>0.38\end{cases}$	$(1-\mu_S)\times\begin{cases}0.98-0.85\frac{\omega_{d,100h}}{0.525} & \frac{\omega_{d,100h}}{0.525}\le0.38\\ 1.06-1.06\frac{\omega_{d,100h}}{0.525} & \frac{\omega_{d,100h}}{0.525}>0.38\end{cases}$	$(-0.124649+[0.869309\times L_{d,100h}\times Z]-[48.04\times\omega_{duff}])\times(L_{d,100h}\times Z)^{-1}$, where conversion factor $Z=0.5\times0.224170$ converts from $kg\,C\,m^{-2}$ to $T\,DM\,ac^{-1}$.	$G_{ag}\times\begin{cases}\widehat{FC}_{d,100h,max}-0.85\omega_{o/*} & \omega_{o/*}<0.38\\ 1.06-1.06\omega_{o/*} & \omega_{o/*}>0.38\end{cases}$
$FC_{d,1000h}$	$G_{ag}(1-\mu_S)\times\times min\left(0.45,[0.8-0.8\times\omega_{d,100h}]\right)$	$max\left(0,0.8-0.8\omega_{o/*}\right)$	$(1-\mu_S)\times max\left(0,0.8-0.8\frac{\omega_{d,1000h}}{0.544}\right)$	$1-\left(\frac{6.6-X}{6.6}\right)^2$, where $X=\begin{cases}1.6107058-(1.4756\times\omega_{duff}) & \omega_{duff}\le0.7\\ 0.5579\times exp(-3[\omega_{duff}-0.7]) & \omega_{duff}>0.7\end{cases}$	$G_{ag}\times\left(\widehat{FC}_{d,1000h,max}-0.8\times\omega_{o/*}\right)$
$FC_{l,1h}$	$G_{ag}\times FA_{w,Cr}$	CF	See LPJ-GUESS-SPITFIRE	n/a	$G_{ag}\times FA_{w,Ca+Cr}\times CF$
$FC_{l,10h}$	$G_{ag}\times FA_{w,Cr}\times0.05$	$0.05CF$	See LPJ-GUESS-SPITFIRE	n/a	$G_{ag}\times FA_{w,Ca+Cr}\times CF$
$FC_{l,100h}$	0	See JSBACH-SPITFIRE	See JSBACH-SPITFIRE	n/a	$G_{ag}\times FA_{w,Ca+Cr}\times CF$
$FC_{l,1000h}$	0	See JSBACH-SPITFIRE	See JSBACH-SPITFIRE	n/a	$G_{ag}\times FA_{w,Ca+Cr}\times0.05CF$
$FC_{l,leaf}$	n/a	n/a	n/a	0.98 if crown fire ($FA_{w,Cr}=1$), 0 otherwise (woody PFTs only).	n/a
$FC_{l,grass}$	$\begin{cases}1.0 & \omega_{l,g/*}<0.18\\ 1.11-0.62\omega_{l,g/*} & 0.18\le\omega_{l,g/*}\le0.73\\ 2.45-2.45\omega_{l,g/*} & \omega_{l,g/*}>0.73\end{cases}$	See JSBACH-SPITFIRE	$G_{ag}\times FC_{d,1h}$	0.9	See JSBACH-SPITFIRE
$FC_{l,stem}$	n/a	n/a	n/a	Fine branches: 0.98 if crown fire ($FA_{w,Cr}=1$), 0 otherwise. Other wood, roots: 0.	n/a

Rabin et al. (2017, *Geosci. Mod. Dev.*)

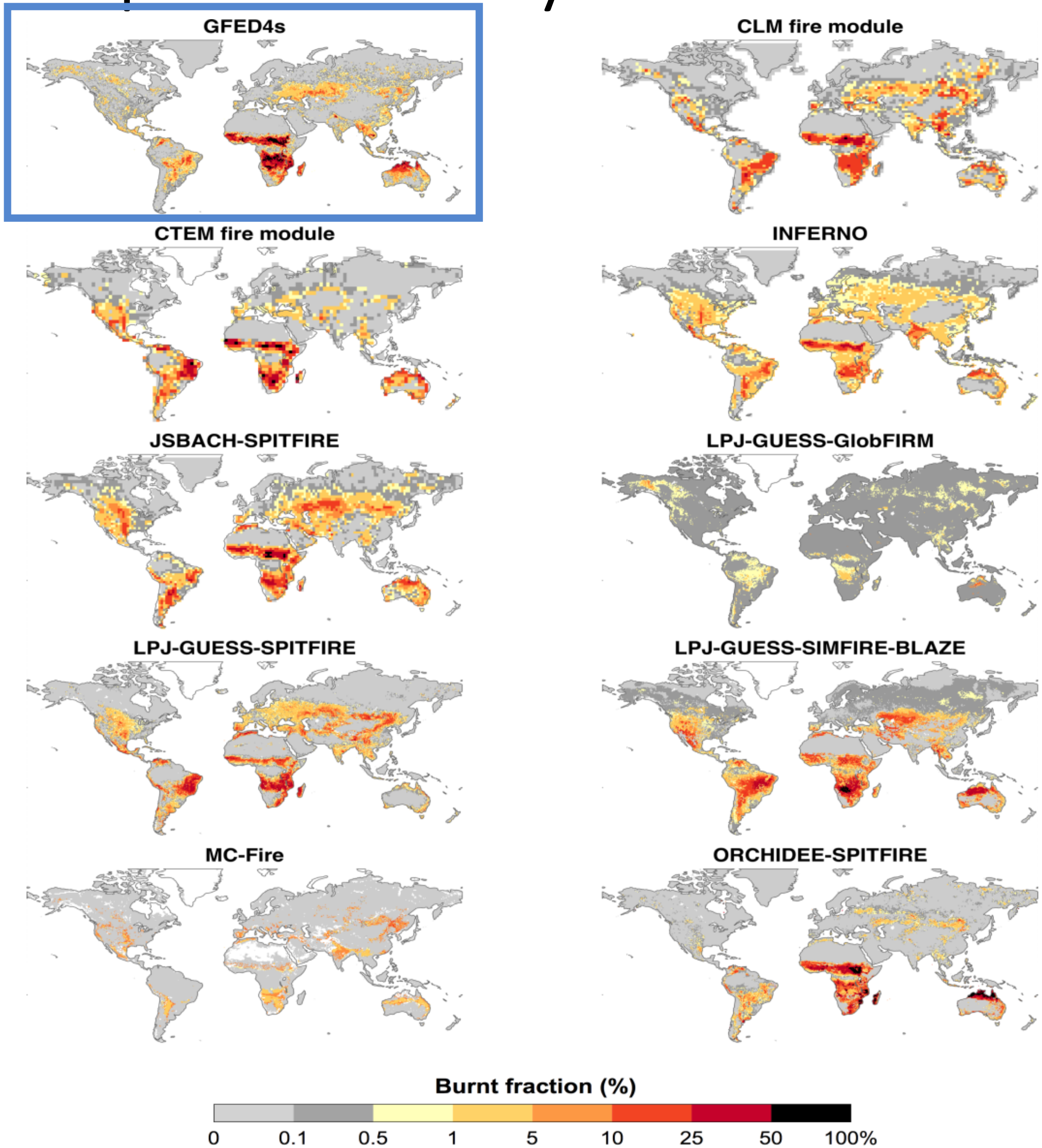
Burned area trends



Hantson et al. (in prep.)

Spatial pattern of present day burned area

- Most: Too much BA in tropics, not enough elsewhere
- Too much BA in Med. Basin, W. USA
- Too much BA in S. America, too little in Africa & Australia



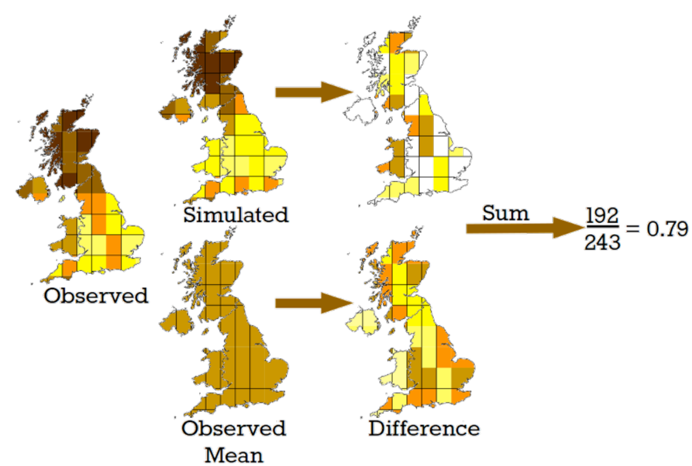
Hantson et al. (in prep.)

Benchmarking (Kelley et al., 2013)

- Quantify how well a model performs across a comprehensive range of important processes.
- Take advantage of the large number of global datasets to evaluate key processes in DGVMs.
- Allows identification of model weaknesses and processes that require improvement.
- Allows model inter-comparison.
  - Using specifically designed metrics to quantify differences between model and observation (Kelley et al., 2013, BG).

Normalized mean error:

$$\mathrm{NME} = \sum_i |y_i - x_i| / \sum_i |x_i - \bar{x}|$$



Benchmarking results

	burnt area			fire C emission	fire seasonality		carbon in vegetation
	GFED4s	GFED4	Inter-annual variability	GFAS	concentration	phase	Avitabile et al. 2016
mean	1	1	1	1	1		1
random	1.18	1.14	1.3	1.21	1.33	0.43	1.33
CLM	0.64	0.69	0.96	0.82	1.4	0.44	0.72
CTEM	0.78	0.85	1.27	0.94	1.16	0.44	0.9
JULES-INFERNO	0.69	0.77	1.21	0.78	1.44	0.47	0.89
JSBACH-SPITFIRE	0.78	0.89	0.86	1.00	1.32	0.43	
LPJ-GUESS-GlobFIRM	0.75	0.71	1.05	1.72			0.81
LPJ-GUESS-SPITFIRE	0.84	0.98	0.89	0.95	1.07	0.39	0.72
LPJ-GUESS-SIMFIRE-BLAZE	0.83	0.98	1.29	0.97	1.34	0.43	0.71
MC2	0.8	0.79	0.88	0.96			0.85
ORCHIDEE-SPITFIRE	0.69	0.82	1.45	1.18	1.05	0.38	0.73

Hantson et al. (in prep.)

Spinoff papers

- Patterns: Emissions, seasonality
- Sensitivity runs: Drivers of fire, diagnosing model behavior
- Regional analyses: Boreal, Mediterranean
- Fire impacts: Vegetation, fuel consumption, water cycling

Acknowledgements

- Stijn Hantson, Almut Arneth
- FireMIP collaborators

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  - EU FP7 projects BACCHUS (grant agreement no. 603445) and LUC4C (grant agreement no. 603542)
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